Project Title:
Self-Consistent Kinetic Simulations of the Global Solar Wind Evolution

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Project Information:
One of the fundamental problems of solar physics is the origin of the solar wind, which is a key element of the Sun-Earth connection. Because the solar wind becomes collisionless at an early stage of acceleration near the Sun, the acceleration depends on kinetic processes in the coronal plasma. A broad consensus has emerged over the past decade attributing the generation of the fast wind in coronal holes to the dissipation of ion cyclotron waves. However, although a number of investigations of this mechanism have been carried out, two crucial questions remain to be answered: What is the character of the necessary waves? and What is the detailed kinetic response of the plasma?

These questions cannot be answered without understanding how the kinetic processes responsible for the solar wind generation are coupled to its global evolution. The coronal plasma is propelled away from the Sun by a macroscopic force determined by microscopic particle distributions. In turn, the large-scale force shapes the distribution as the particles propagate through the corona. Therefore, analysis of the cross-scale interactions is essential for a working model of the solar wind. This is the goal of the present proposal. Extensive numerical simulations designed to calculate self-consistently the ion distribution, the solar wind acceleration, and the spectrum of waves, which drive the acceleration, will be carried out. This will approach allow the project team to develop a global kinetic description of the fast solar wind. The obtained results will be tested against several types of remote and situ observational data.

The solar wind originating in coronal holes is known to be the dominant heliospheric phenomenon responsible for the geomagnetic activity during the declining phase of the solar cycle. In addition, understanding how and where the solar wind is energized can improve the models of the ambient medium through which solar ejections and their attendant shocks develop and travel from the Sun to the Earth. As a result, the present work can increase the accuracy of space weather forecasting. The expected theoretical findings can further enhance the observational capabilities of future NASA missions relating to the coronal origin of the solar wind, such as Solar Orbiter/Sentinels and Solar Probe Plus.

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